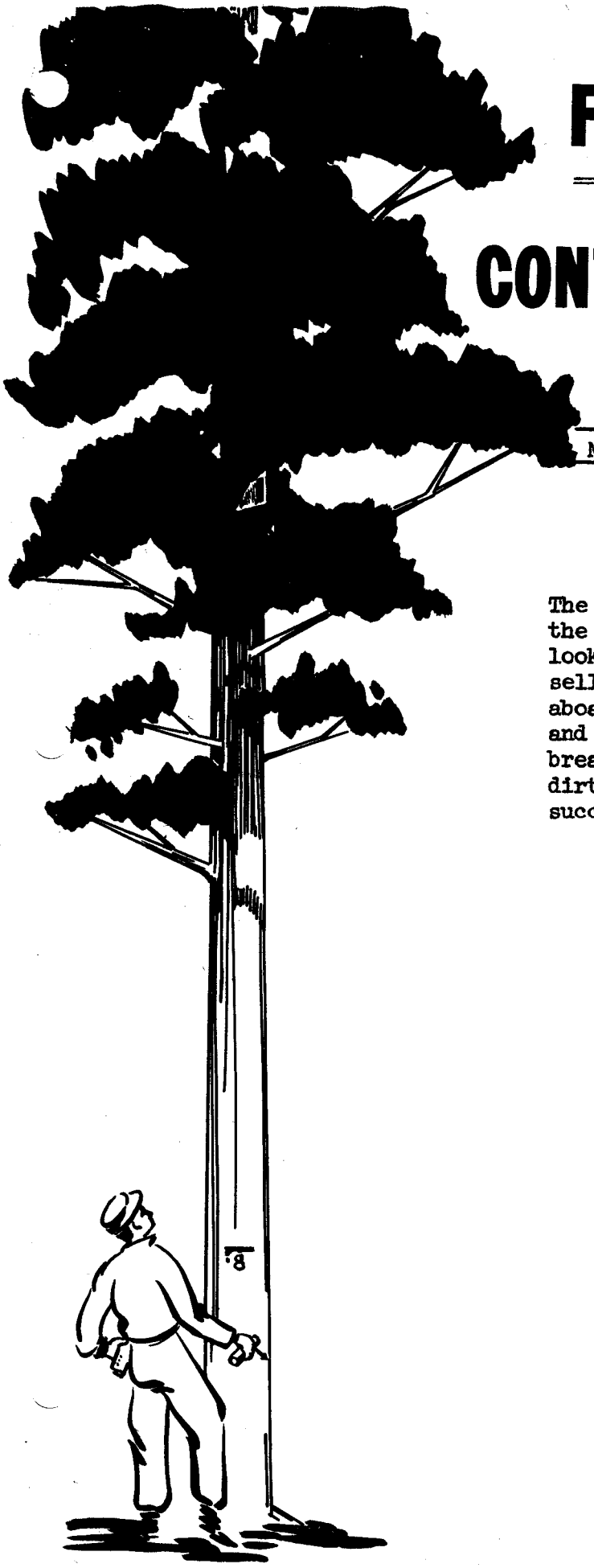
FOREST CONTROL by CONTINUOUS INVENTORY



"Today I have grown taller from walking with the trees."

...Karle Wilson

Milwaukee, Wis. January, 1964 No. 118

The New Year, the New Year. Everywhere the New Year. The Old Year was already looked upon as dead; and its effects were selling cheap, like some dead mariner's aboardship. Its patterns were Last Year's and going at a sacrifice, before its breath was gone. Its treasures were mere dirt, beside the riches of its unborn successor.

CHARLES JOHN HUFFHAM DICKENS

The Chimes. Fourth Quarter.

January 1, 1964

A Statistical Check Computer Program for the I.B.M. 1620

C.F.I. can provide the forester and business manager with a vast number of results. Every inventory is only a sample of the total forest, and results obtained from inventory data analyses must be inferred from the sample taken. The results are only approximations, however, but it is assumed when taking the sample that data gathered are representative of the total forest. Consequently, a risk of being wrong is accepted when results are stated. What is required as a supplement to the results is a measure of their reliability. The Statistical Check provides a means to determine this reliability. Our Newsletter this month deals with a Statistical Check procedure that should be used on all inventories, and it is the first in a series of Newsletters dealing with computer applications to the Region 9 C.F.I. job.

The computer program presented was written to be used on I.B.M. 1620 computers. The 1620 was chosen particularly because many universities possess installations of this type which can be used by those operating a C.F.I. system. This program is not, however, restricted to a 1620. With a few minor modifications, which will be apparent to a computer programmer, the program, written for FORTRAN II, can be compiled and run on larger computers such as the I.B.M. 7090. Prepared FORTRAN source decks of the program are available upon request at the U. S. Forest Service Regional Office in Milwaukee.

The compiled program consists of one object deck which will compute area break statistical checks on volume (or growth) estimates, area estimates and volume and area estimates combined, and punch results. For various area breaks common to C.F.I. in Region 9 both pulpwood and sawlog quantitative input data can be used. Fourteen area breaks segregated into administrative, operational, physical-graphical and ecological groups can also be included in the input data. A separate run is required for pulpwood or sawlog input data, although it is not necessary to reload the program object deck after each run. When an analysis is completed the program branches to the beginning of the routine and calls for more input data to be analyzed.

Specification of pulpwood or sawlog data is made by using a Parameter Card which precedes the input data when the latter are read into the machine. The Parameter Card layout appears on page 5, and instructions for its use are presented with the program operating instructions. Input and output card layouts for pulpwood and sawlog data also appear on this page. The only input card field titles that need conform with those that appear in the card layouts are: (1) the number of plots in a particular area break; (2) the sum of the plot volumes; (3) the sum of the plot volumes squared, and (4) the expanded area. It is suggested that the area break columns for input cards be used as designated on the card layouts; there is a fixed correspondence between input card columns and output card columns.

The original object deck was compiled using FORTRAN II on a 60,000 bit storage 1620 with the indirect addressing feature and automatic floating point multiply and divide. A listing of the source deck from which program object decks are generated appears on page 6, and a corresponding flow diagram is presented on page 7.

Statistical Procedure Leaflet #9 which accompanied C.F.I. Newsletter #79, October, 1960 contains the formulas used in the Statistical Check Program. All results are calculated at a confidence level of approximately 95% with the assumption that sample plots are 1/5-acre in size. The numerical constants in source card numbers 00037 and 00075 for other plot sizes should be changed, for example, from 5.0 for a 1/5-acre plot to 7.0 for a 1/7-acre plot.

Limits of error are computed as non-percentage figures and must be multiplied by 100 to yield percentage results. When the computed results exceed the specified size of the output fields, the machine types and punches an error message.

James N. Hool
Department of Forestry & Conservation
Purdue University
Lafayette, Indiana

This program was first used under the direction of the consulting firm of George Banzhaf & Company, Milwaukee, Wisconsin. The CFI case involved 1,100 permanent plots of fixed radius, established on the timber lands of the Cleveland-Cliffs Iron Co. in 1961

Operating Instructions for the 1620 STATISTICAL CHECK ROUTINE

Use of the Parameter Card

Card Column	
1	1 punch for pulpwood input data 2 punch for sawlog input data
3-6	Punch N the total number of plots in the sample as a right-justified integer.
8-11	Punch the number of data input cards for a particular run as a right-justified integer.

Machine Operating Instructions

1.	Clear core storage:	RESET, INSERT, type 160001000000, RELEASE, START, after a couple of seconds press INSTANT STOP, RESET.
2.	Switch settings:	Sense Switches #1, #2, #3, #4 to ON or OFF. Parity Switch to STOP I/O Switch to STOP Overflow Switch to PROGRAM
3.	Load program object deck:	Place object deck in reader feed Press LOAD Press READER START to read last card of object deck.
4.	Load program subroutine deck:	Place subroutine deck in reader feed Press LOAD Press READER START to read last card of subroutine deck.

Machine Operating Instructions (continued)

5. Enter data to be processed:

Place Parameter Card ahead of data input cards.

Place Parameter Card and data input cards in reader feed.

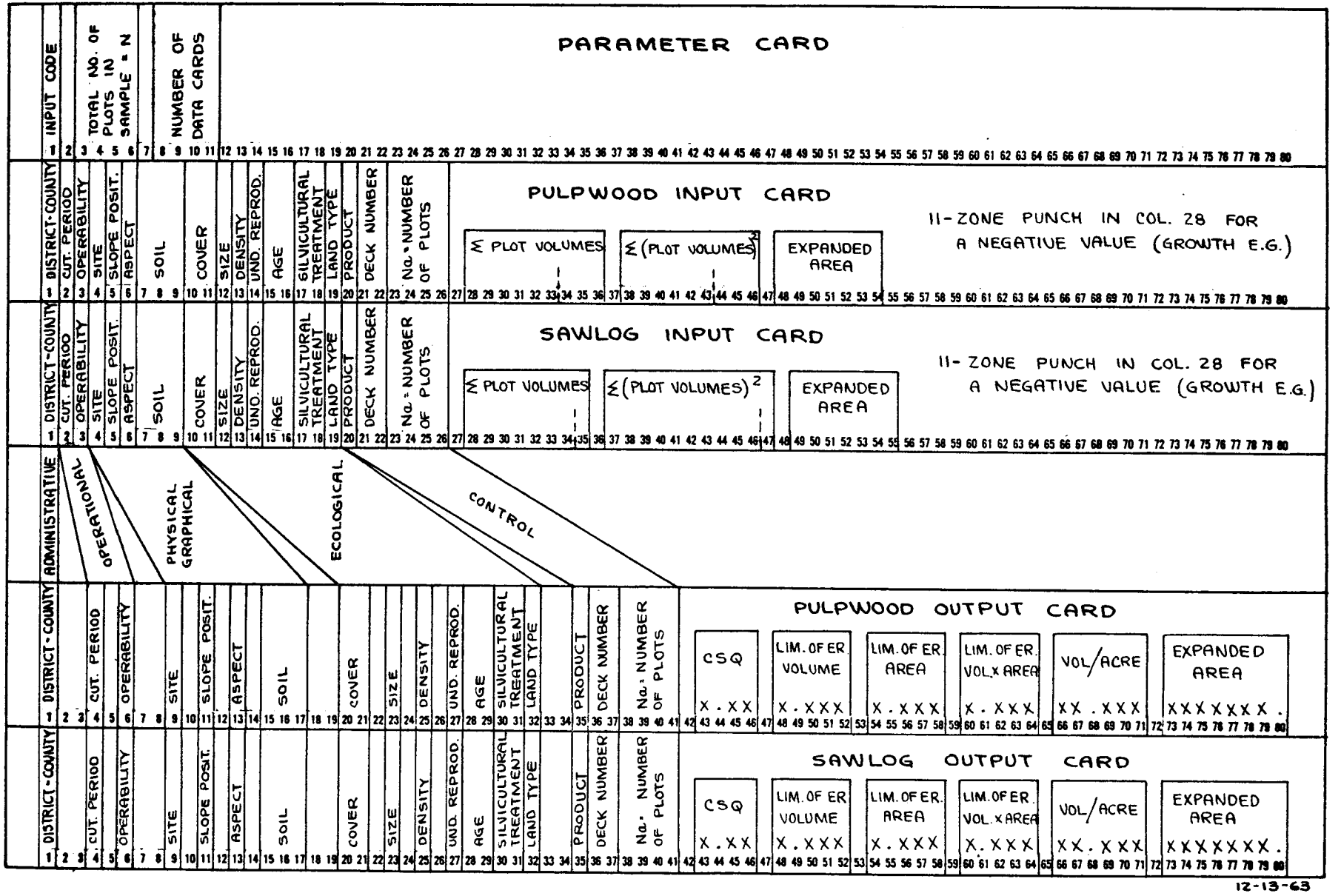
Press START on console

Press READER START and PUNCH START

Press READER START to read last data input card.

6. Remove output data from punch hopper and list.

STATISTICAL CHECK PROGRAM
CARD LAYOUTS

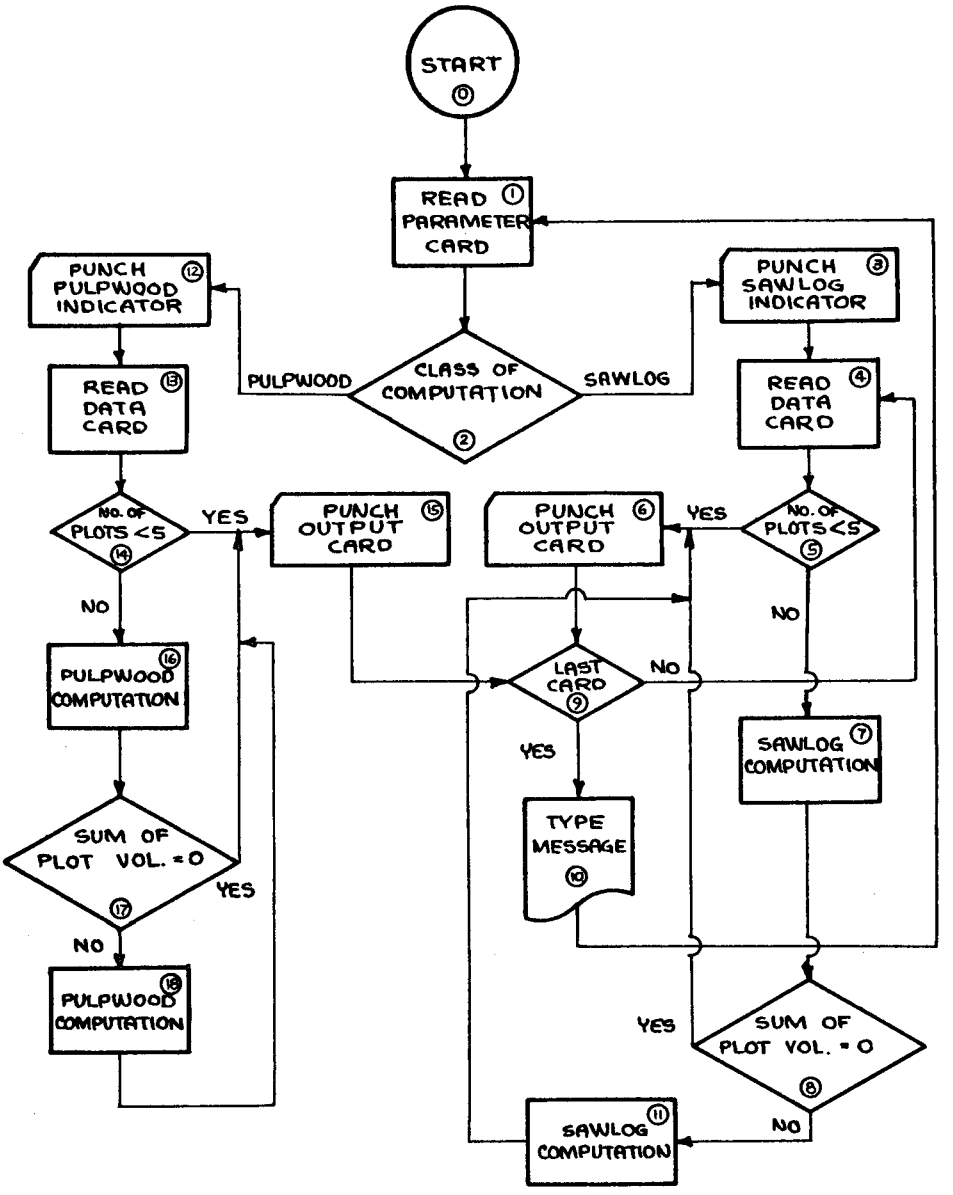


12-13-63

Card Columns		1	3-5	7 - 72	79-80
Identification		C		COMBINED PULPWOOD-SAWLOG STATISTICAL CHECK ROUTINE FOR FOREST INV.	1
		C		C.F.I. DIVISION, S-PF, REGION 9, USFS-MILWAUKEE, WIS	2
Initialization				IPLOTS = 5	3
			10	READ 20, IL1, FN, IL2	4
			20	FORMAT (I1, 1X, F4.0, 1X, I4)	5
				IF (IL1 - 1) 30, 30, 210	6
Pulpwood			30	PUNCH 40	7
			40	FORMAT (27HSTATISTICAL CHECK, PULPWOOD)	8
				I = 0	9
	Card Read		110	READ 60, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	10
				1IE5, IE6, IE7, IC1, IC2, NA, SX, SQX, EXPA	11
			60	FORMAT (6I1, I3, I2, 3I1, 2I2, 2I1, I2, I4, 1X, F9.3, 1X,	12
				1F9.3, 1X, F7.0)	13
				IF (NA - 5) 70, 120, 120	14
	If number of plots is less than five		70	PUNCH 80, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	15
				1IE5, IE6, IE7, IC1, IC2, NA, EXPA	16
			80	FORMAT (I1, 2X, I1, 1X, I1, 2X, I1, 1X, I1, 1X, I1, 1X, I3, 2X,	17
				1I2, 1X, I1, 1X, I1, 1X, I1, I2, I2, I1, 2X, I1, I2, I4,	18
				227H NO. OF PLOTS LESS THAN 5, 3X, F9.0)	19
				I = I + 1	20
				IF (IL2 - I) 390, 390, 110	21
	Computation		120	FNA = NA	22
				T1 = (FN - FNA)/(FN * FNA)	23
				EA = 2.0 * SQRTF(T1)	24
				IF (SX) 170, 130, 170	25
	If ≤ plot volume equals zero		130	PUNCH 140, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	26
				1IE5, IE6, IE7, IC1, IC2, NA, EA, EXPA	27
			140	FORMAT (I1, 2X, I1, 1X, I1, 2X, I1, 1X, I1, 1X, I1, 1X, I3, 2X,	28
				1I2, 1X, I1, 1X, I1, 1X, I1, I2, I2, I1, 2X, I1, I2, I4,	29
				211H VOL. ZERO, F6.3, 13X, F9.0)	30
				I = I + 1	31
				IF (IL2 - I) 390, 390, 110	32
	Computation and Output		170	B = FNA * SQX/SX**2 - 1.0	33
				EV = 2.0 * SQRTF(B/(FNA - 1.0))	34
				CSQ = B * FNA/(FNA - 1.0)	35
				EVA = 2.0 * SQRTF(B/(FNA - 1.0) + T1)	36
				VPERA = 5.0 * SX/FNA	37
				PUNCH 180, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	38
				1IE5, IE6, IE7, IC1, IC2, NA, CSQ, EV, EA, EVA, VPERA, EXPA	39
			180	FORMAT (I1, 2X, I1, 1X, I1, 2X, I1, 1X, I1, 1X, I1, 1X, I3, 2X,	40
				1I2, 1X, I1, 1X, I1, 1X, I1, I2, I2, I1, 2X, I1, I2, I4,	41
				2F5.2, F6.3, F6.3, F6.3, F7.3, F9.0)	42
				I = I + 1	43
				IF (IL2 - I) 390, 390, 110	44
Sawlog			210	PUNCH 220	45
			220	FORMAT (25HSTATISTICAL CHECK, SAWLOG)	46
				I = 0	47
	Card Read		290	READ 240, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	48
				1IE5, IE6, IE7, IC1, IC2, NA, SX, SQX, EXPA	49
			240	FORMAT (6I1, I3, I2, 3I1, 2I2, 2I1, I2, I4, 1X, F8.1, 1X,	50
				1F11.1, 1X, F7.0)	51
				IF (NA - 5) 250, 300, 300	52
	If number of plots is less than five		250	PUNCH 260, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	53
				1IE5, IE6, IE7, IC1, IC2, NA, EXPA	54
			260	FORMAT (I1, 2X, I1, 1X, I1, 2X, I1, 1X, I1, 1X, I1, 1X, I3, 2X,	55
				1I2, 1X, I1, 1X, I1, 1X, I1, I2, I2, I1, 2X, I1, I2, I4,	56
				227H NO. OF PLOTS LESS THAN 5, 3X, F9.0)	57
				I = I + 1	58
				IF (IL2 - I) 390, 390, 290	59
	Computation		300	FNA = NA	60
				T1 = (FN - FNA)/(FN * FNA)	61
				EA = 2.0 * SQRTF(T1)	62
				IF (SX) 350, 310, 350	63
	If ≤ plot volume equals zero		310	PUNCH 320, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	64
				1IE5, IE6, IE7, IC1, IC2, NA, EA, EXPA	65
			320	FORMAT (I1, 2X, I1, 1X, I1, 2X, I1, 1X, I1, 1X, I1, 1X, I3, 2X,	66
				1I2, 1X, I1, 1X, I1, 1X, I1, I2, I2, I1, 2X, I1, I2, I4,	67
				211H VOL. ZERO, F6.3, 13X, F9.0)	68
				I = I + 1	69
				IF (IL2 - I) 390, 390, 290	70
	Computation and Output		350	B = FNA * SQX/SX**2 - 1.0	71
				EV = 2.0 * SQRTF(B/(FNA - 1.0))	72
				CSQ = B * FNA/(FNA - 1.0)	73
				EVA = 2.0 * SQRTF(B/(FNA - 1.0) + T1)	74
				VPERA = 5.0 * SX/FNA	75
				PUNCH 360, IA1, IO1, IO2, IP1, IP2, IP3, IP4, IE1, IE2, IE3, IE4,	76
				1IE5, IE6, IE7, IC1, IC2, NA, CSQ, EV, EA, EVA, VPERA, EXPA	77
			360	FORMAT (I1, 2X, I1, 1X, I1, 2X, I1, 1X, I1, 1X, I1, 1X, I3, 2X,	78
				1I2, 1X, I1, 1X, I1, 1X, I1, I2, I2, I1, 2X, I1, I2, I4,	79
				2F5.2, F6.3, F6.3, F6.3, F7.0, F9.0)	80
				I = I + 1	81
				IF (IL2 - I) 390, 390, 290	82
Termination			390	TYPE 400	83
			400	FORMAT (51H ENTER PARAMETER CARD AND DATA---PRESS READER START)	84
				GO TO 10	85
				END	86

JAMES N. HOOL
12-13-63

FLOW DIAGRAM FOR 1620 STATISTICAL CHECK PROGRAM



BLOCK #	SOURCE CARD #
0	1 - 3
1	4 - 5
2	6
3	45 - 47
4	48 - 51
5	52
6	53 - 57, 64 - 68, 76 - 80
7	60 - 62
8	63
9	20 - 21, 31 - 32, 43 - 44, 58 - 59, 69 - 70, 81 - 82
10	83 - 85
11	71 - 75
12	7 - 9
13	10 - 13
14	14
15	15 - 19, 26 - 30, 38 - 42
16	22 - 24
17	25
18	33 - 37

JAMES N. HOOL
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October, 1960

STATISTICAL PROCEDURE LEAFLET #9

CALCULATING THE LIMIT OF ERROR IN AREA AND VOLUME COMBINED

Since there is a limit of error for both the estimated average volume and the estimated area, when we multiply the two to get the total volume on any particular breakdown we shall wish to calculate the limit of error for the product. The limit of error for this product is very easily calculated by adding data used to calculate the individual limits of error in volume and area as shown below.

Formulae for limits of error 1/:

In VOLUME	In AREA	In combined AREA x VOLUME
$Ev = \pm 2\sqrt{\frac{B}{Na - 1}}$	$Ea = \pm 2\sqrt{\frac{N - Na}{N \times Na}}$	$Eva = \pm 2\sqrt{\frac{B}{Na - 1} + \frac{N - Na}{N \times Na}}$

WHERE:

Ev	=	limit of error in volume
Ea	=	limit of error in area
Eva	=	limit of error in combined area and volume
N	=	total number of plots on whole forest
Na	=	number of plots in an area breakdown
ΣX	=	sum of individual plot volumes
ΣX^2	=	sum of squares of individual plot volumes
$(\Sigma X)^2$	=	square of the sum of individual plot volumes

$$B = \frac{Na\ (\Sigma X^2)}{(\Sigma X)^2} - 1$$

For EXAMPLE when:

$N = 661$ plots $\qquad \frac{\Sigma X^2}{(\Sigma X)^2} = 93.081 = 1594.002$

$Na = 31$ plots

$$B = \frac{31\ (93.081)}{1594.002} - 1, \text{ or } .810$$

Limit of error-VOLUME	Limit of error-AREA	Limit of error-AREA x VOLUME
$Ev = \pm 2\sqrt{\frac{.810}{31-1}}$	$Ea = \pm 2\sqrt{\frac{661-31}{661x31}}$	$Eva = \pm 2\sqrt{\frac{.810}{31-1} + \frac{661-31}{661x31}}$
$= \pm 2\sqrt{\frac{.810}{30}}$	$= \pm 2\sqrt{\frac{630}{20491}}$	$= \pm 2\sqrt{\frac{.810}{30} + \frac{630}{20491}}$
$= \pm 2\sqrt{.027000}$	$= \pm 2\sqrt{.030745}$	$= \pm 2\sqrt{.057745}$
$= \pm 2\ (.164)$	$= \pm 2\ (.175)$	$= \pm 2\ (.240)$
$= \pm .328$, or $\pm 33\%$	$= \pm .350$, or $\pm 35\%$	$= \pm .480$, or $\pm 48\%$

1/ The 2 in each formula is approximate "t" factor for 95% probability. See Statistical Procedures Leaflet #4 for discussion of probability.

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